TOPIC 15 – ENERGETICS
15.3: ENTROPY

IB Chemistry

T15D12

15.3 Entropy - 1.5 hours

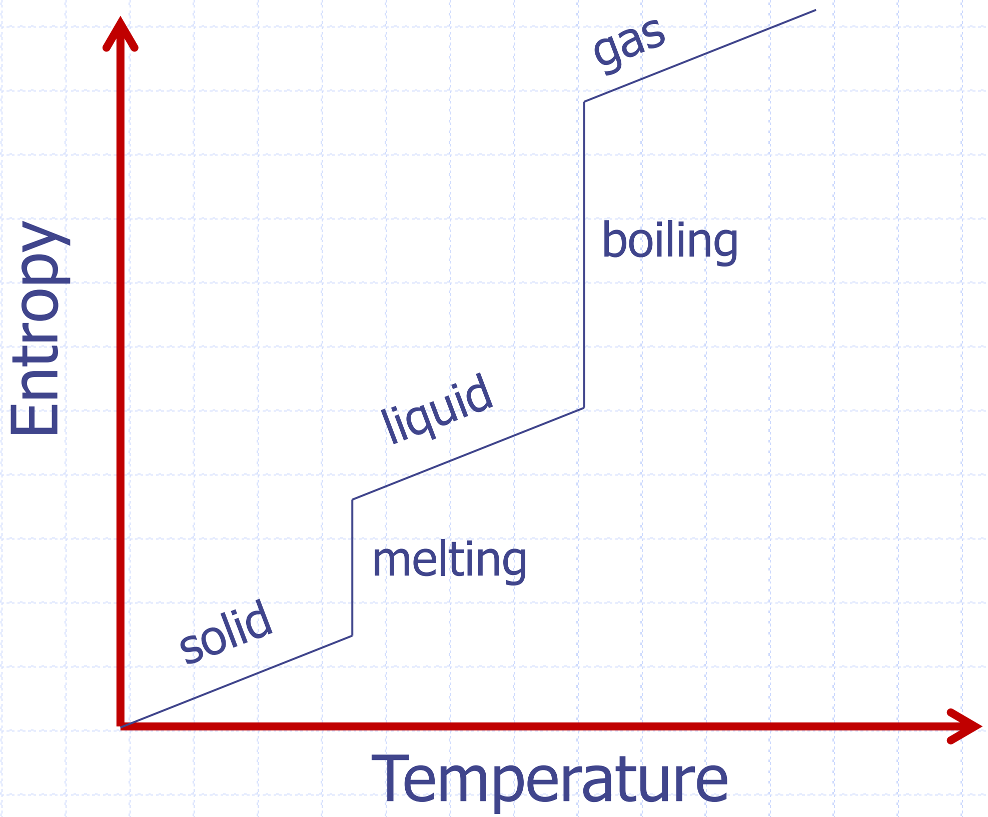
- 15.3.1 **State** and **explain** the factors that increase the entropy in a system. (3)
- 15.3.2 **Predict** whether the entropy change (ΔS) for a given reaction or process is positive or negative. (3)
- 15.3.3 **Calculate** the standard entropy change for a reaction (ΔS) using standard entropy values(s) . (2)

15.3.1 - Entropy

- 15.3.1 **State** and **explain** the factors that increase the entropy in a system. (3)
- **Entropy** can be regarded as a measure of the disorder or dispersal of energy in a system
- The symbol is , **S**, and the disorder refers to the arrangement of particles (atoms, ions, etc) and the kinetic energies of the particles in a system
- For example, ionic solid vs gas. The gas has significantly greater entropy because its particles are moving rapidly in all directions

15.3.1 – Effect of T on Entropy

- When T is increased, disorder and hence entropy (S) increase.
- Particles vibrate more, move faster, etc.



15.3.1 – Effect of State Change

- The disorder of particles increases from solid to liquid to gas increasing entropy.
- The particle arrangement becomes more orderly when a change in state occurs form gas to liquid to solid, hence the entropy decreases

15.3.1 – Effect of change in amount

- If the number of particles increases, disorder and entropy increase.
- This is especially true of gases
  - $N_2O_4\ (g) \rightarrow 2NO_2\ (g)$
- Conversely, the entropy decreases when the number for particles decreases,
  - $CH_2{=}CH_2\ (g) + H_2\ (g) \rightarrow C_2H_6\ (g)$

15.3.1 – Effect of mixing particles

- The mixing of particles increases disorder, resulting in an increase in entropy.
- If the two sets of particles have different average kinetic energies (diff Temps), then the kinetic energy is randomly dispersed in collisions until a new equilibrium temperature is attained
- Think of dissolving NaCl in a beaker of water, overall entropy will increase

15.3.2 – Entropy Change

- 15.3.2 **Predict** whether the entropy change (ΔS) for a given reaction or process is positive or negative. (3)
- By examination of the reactants and products, the **change in entropy** of a system can be predicted (**ΔS**)
- If the products are more disordered than the reactants, then ΔS_{sys} = positive
- If the products are less disordered than the reactants, then ΔS_{sys} = negative

Chemical reaction or physical change	Entropy Change (ΔS)	Example
Melting	Increase	$H_2O(s) \rightarrow H_2O(l)$
Boiling	Large Increase	$H_2O(l) \rightarrow H_2O(g)$
Condensing	Large Decrease	$H_2O(g) \rightarrow H_2O(l)$
Sublimation	Very Large Increase	$I_2(s) \rightarrow I_2(g)$
Vapor Deposition	Very Large Decrease	$I_2(g) \rightarrow I_2(s)$
Freezing	Decrease	$H_2O(l) \rightarrow H_2O(s)$
Dissolving a solute to form a solution	Generally an Increase (except with highly charge ions)	$NaCl(s) + (aq) \rightarrow NaCl(aq)$
Precipitation	Large Decrease	$Pb^{2+}(aq) + 2Cl^{-}(aq) \rightarrow PbCl_2(s)$
Crystallization from a solution	Decrease	$NaCl(aq) \rightarrow NaCl(s)$
Chemical Reaction: solid or liquid form gas	Large Increase	$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
Chemical Reaction: gases form solid or liquid	Large Decrease	$2H_2S(g) + SO_2(g) \rightarrow 3S(s) + 2H_2O(l)$
Increase in # mol gas	Large Increase	$2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$

15.3.3 – Standard Entropy Change

- 15.3.3 **Calculate** the standard entropy change for a reaction (ΔS) using standard entropy values(s) . (2)
- A change in entropy is represented by ΔS
  - **Units** of S and ΔS = ——— = ———
- Entropy values are absolute values and can be measured experimentally (heat capacities)
- Value of ΔS can be calculated from absolute values of entropies using the following expression
  - $\Delta S^{\theta} = \quad {}^{\theta}_{[products]} - \quad {}^{\theta}_{[reactants]}$

15.3.3 – Entropy Values

- Entropy values (under standard thermo conditions) for selected organic compounds are listed on pages 12 and 13 of the *Chemistry Data Booklet.*
- Example:
  - Calculate the entropy change that occurs during the complete combustion of ethane:
    - $C_2H_6(g) + 3\ ½\ O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$
    - $S^{\theta}_{[C2H6(g)]} = 230$ ——
    - $S^{\theta}_{[O2(g)]} = 205$ ——
    - $S^{\theta}_{[CO2(g)]} = 214$ ——
    - $S^{\theta}_{[H2O(g)]} = 70$ ——

15.3.3 – Entropy Example

- From the previous slide and example
- The equation will be as follows
  - $\Delta S^{\theta} = \quad {}^{\theta}_{[products]} - \quad {}^{\theta}_{[reactants]}$
- $\Delta S^{\theta} = [(2x214) + (3x70)] – [230 + (3.5x205)]$
- $\Delta S^{\theta} = -310$ ___